Receiving and Displaying the AO-51 Telemetry Downlink: a Sound Card DSP Software Modem and a Matching Telemetry Display Program

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What is this all about?

It's all about the satellite telemetry.

Telemetry – n. The science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources, as from space vehicles, to receiving stations for recording and analysis.
[Source: American Heritage Dictionary]

It's all about options: where the telemetry comes from, where it goes and how it gets there.

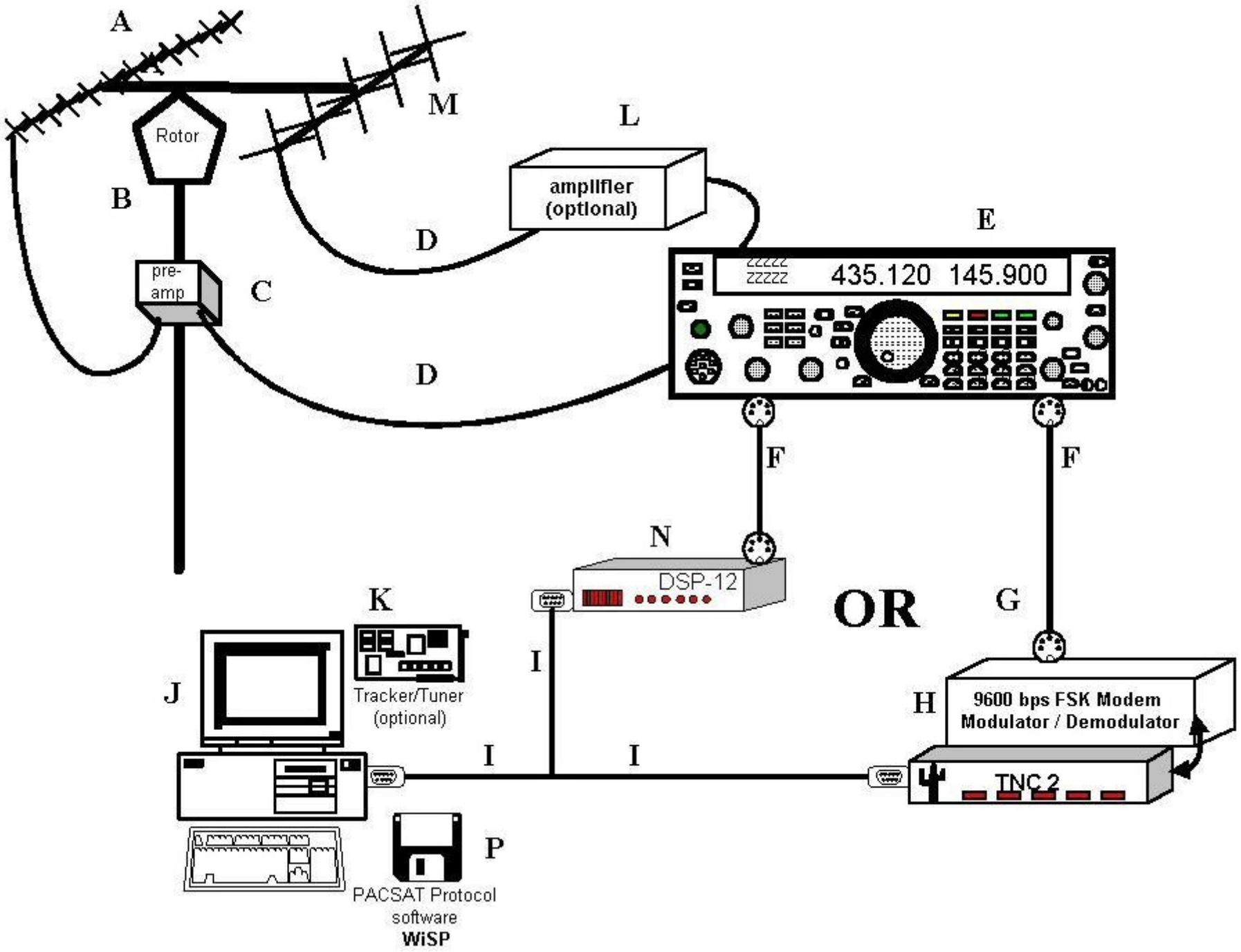
What is this all about?

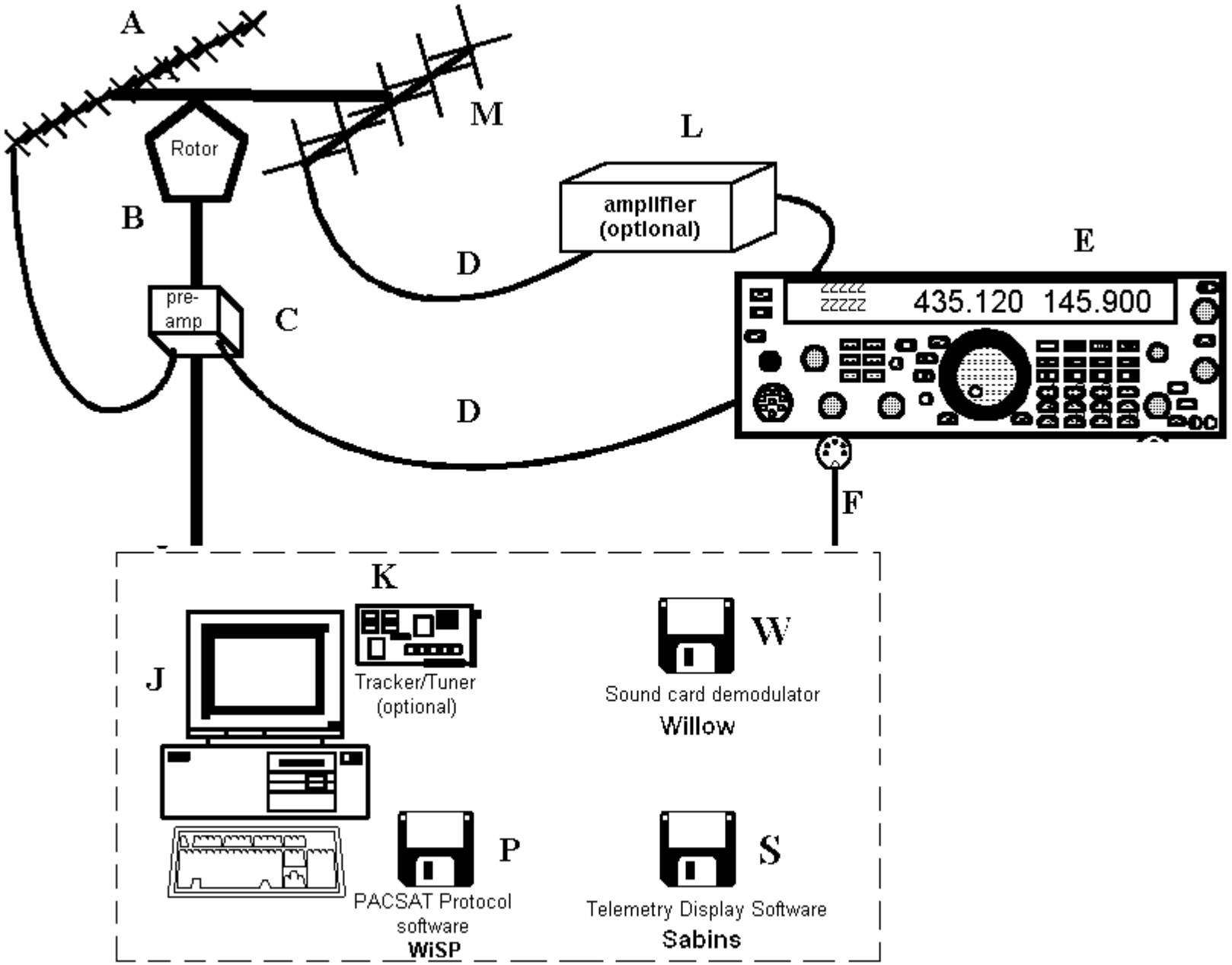
- The telemetry is the ONLY way to know what is happening to many (most?) of the systems on the satellite.
- How much power are the solar panels providing?
- How much power are the radios consuming?
- How long are the eclipses lasting?
- How hot or cold is the spacecraft?

Telemetry provides the answers.

Where does this fit in?

- The sound card modem (codename “Willow”) replaces both the hardware 9600 baud modem and TNC in a typical satellite groundstation.
- The telemetry display program (“Sabins”) is specifically designed to work with Willow.


A
M
L
Rotor
B
amplifier
(optional)
D
E
pre-
amp
C
435.120 145.900
D
F
F
N
DSP-12
OR
K
G
J
Tracker/Tuner
(optional)
I
H
9600 bps FSK Modem
Modulator / Demodulator
I
I
TNC 2
P
PACSAT Protocol
software
WiSP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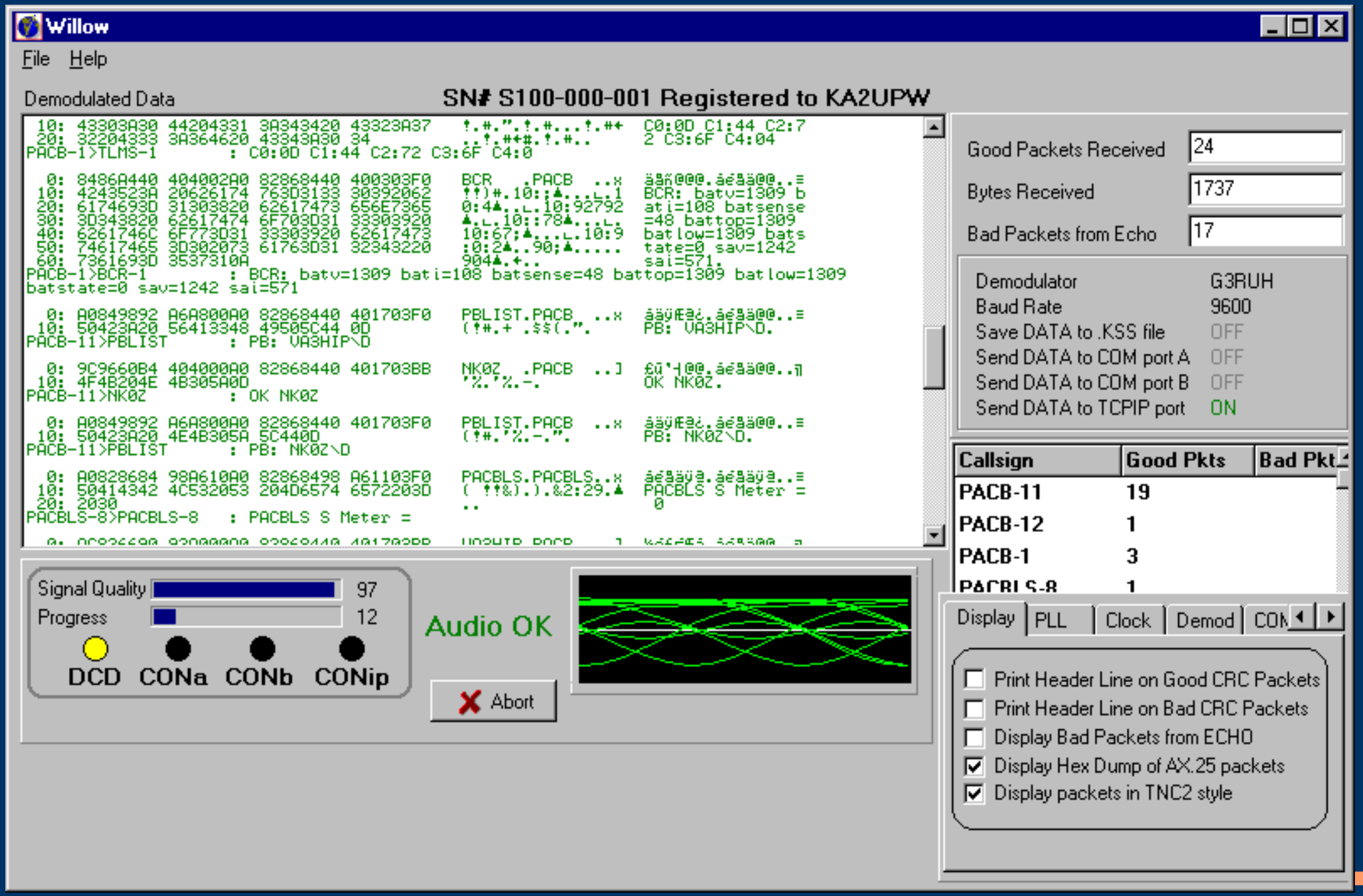
435.120 145.900
D
F
K
J
Tracker/Tuner
(optional)
W
Sound card demodulator
Willow
P
PACSAT Protocol
software
WiSP
S
Telemetry Display Software
Sabins

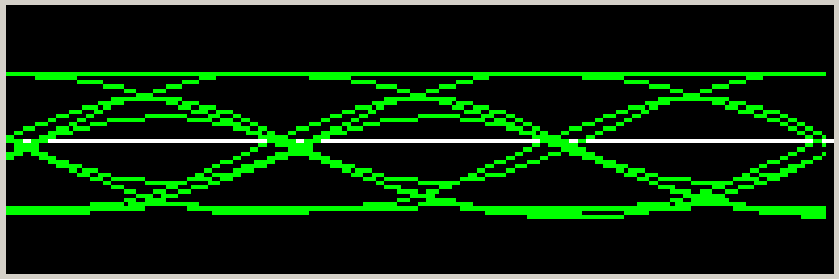
Sound card DSP based solution

- “Willow,” a software modem/TNC that replaces the typical hardware modem and TNC
- Reduces the hardware requirements for a digital station to receive telemetry
- Appeals more to newcomers and students due to reduced costs
- Requires the radio receiver (well, *sometimes*)

Willow


Willow
File Help
Demodulated Data
SN# S100-000-001 Registered to KA2UPW
PACB-1>TLMS-1 : C0:0D C1:44 C2:72 C3:6F C4:0
PACB-1>BCR-1 : BCR: batv=1309 bati=108 batsense=48 battop=1309 batlow=1309
batstate=0 sav=1242 sai=571
PACB-11>PBLIST : PB: VA3HIP\D
PACB-11>NK0Z : OK NK0Z
PACB-11>PBLIST : PB: NK0Z\D
PACB-8>PACBLS-8 : PACBLS S Meter =
Good Packets Received 24
Bytes Received 1737
Bad Packets from Echo 17
Demodulator G3RUH
Baud Rate 9600
Save DATA to .KSS file OFF
Send DATA to COM port A OFF
Send DATA to COM port B OFF
Send DATA to TCPIP port ON
Callsign
Good Pkts
Bad Pkt
PACB-11 19
PACB-12 1
PACB-1 3
Signal Quality 97
Progress 12
DCD CONa CONb CONip
Audio OK
Abort
Display PLL Clock Demod
Print Header Line on Good CRC Packets
Print Header Line on Bad CRC Packets
Display Bad Packets from ECHO
Display Hex Dump of AX.25 packets
Display packets in TNC2 style

Willow



Enable Eye Diagram

Callsign	Good Pkts	Bad Pkts
PECHO-11	503	276
PACBLS-8	17	3
PECHO-12	11	
PACB-1	138	47

Signal Quality 100

Progress 0

DCD CONa CONb CONip

No Audio.

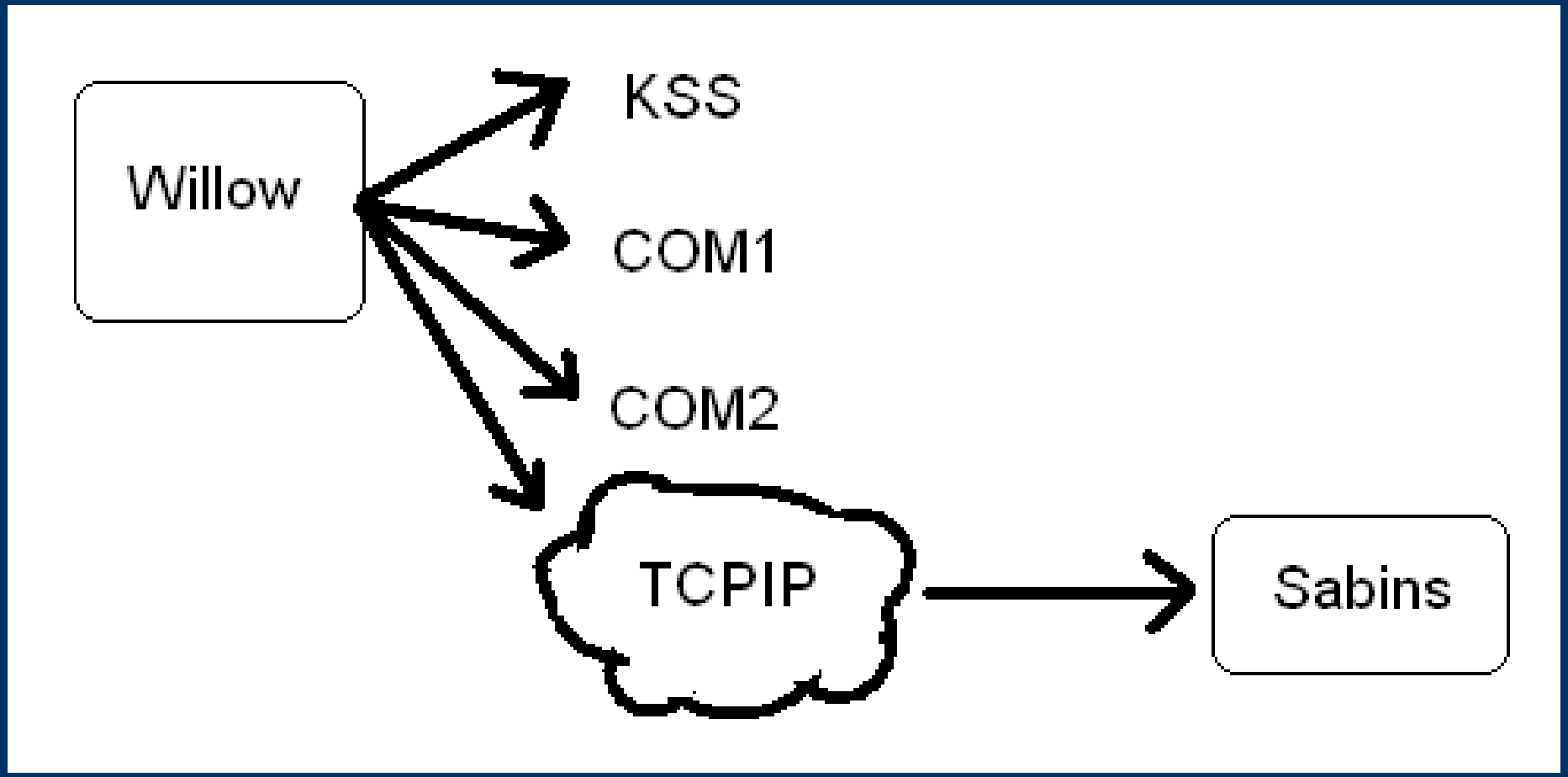
Willow – options

- Satellite telemetry (AX.25 packets) can be retrieved from a recording or “live” from a sound card connected to a radio receiver's discriminator
- Displays received packets in TNC2 style and/or as hex dumps
- Displays and counts good packets and bad packets *from Echo*

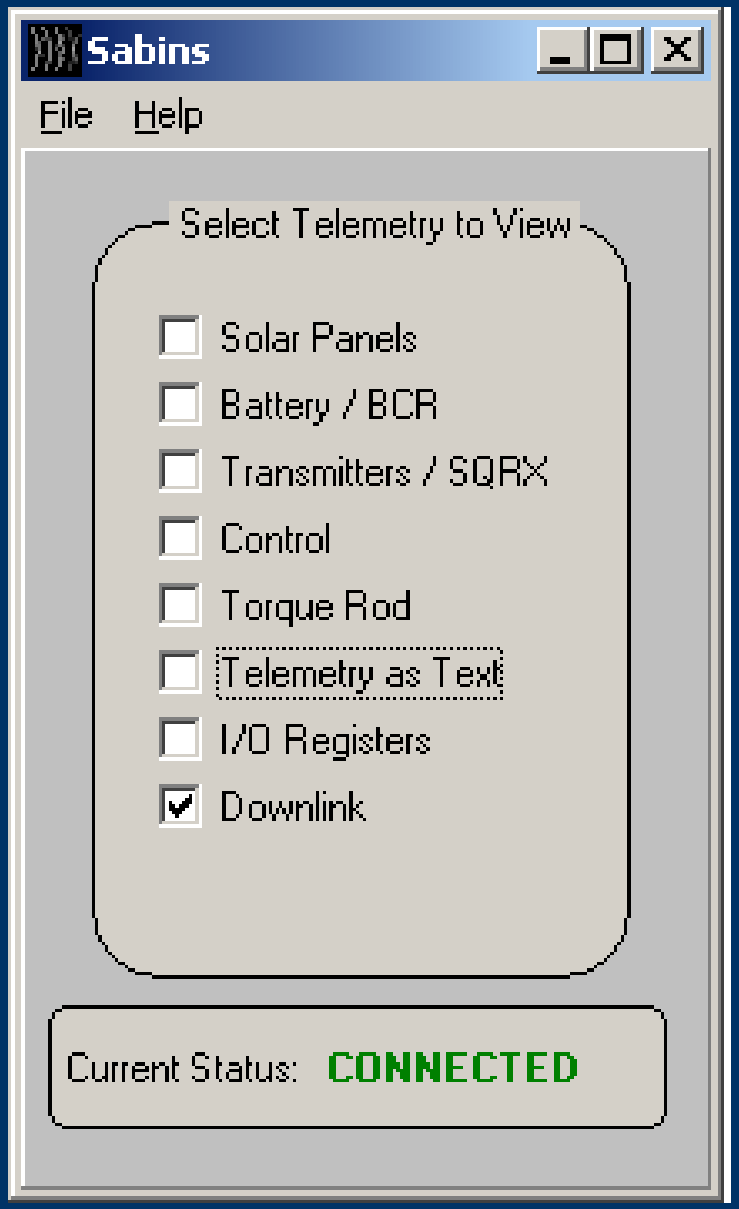
Willow – more options

- Saves audio to a file for later processing
- Saves received AX.25 packets to a .KSS file
- Sends received packets out over a serial port
- Sends the same packets out a second serial port
- Sends the AX25 packets via TCPIP to another program (Willow or a telemetry distribution program)

Willow – options



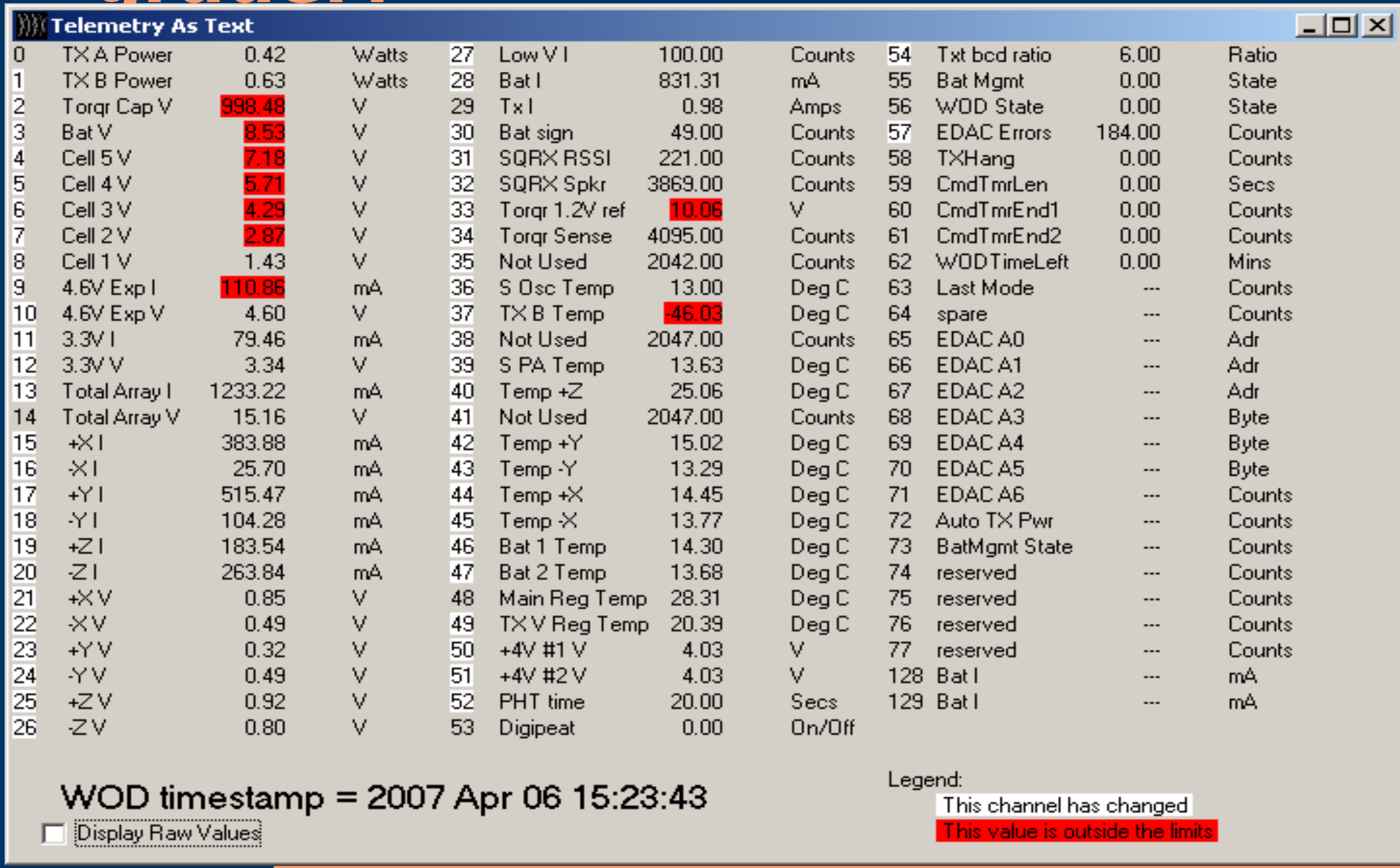
Sabins


Sabins
File
Help
Select Telemetry to View
Solar Panels
Battery / BCR
Transmitters / SQRX
Control
Torque Rod
Telemetry as Text
I/O Registers
Downlink
Current Status: CONNECTED

Sabins

- Reads telemetry equations from ECHOCOEF.CSV file
- Modifies easily for use with *another* satellite (just change the photos and use a new coefficients file)
- Contains more than just rows and columns of numbers
- Makes it interesting for the newcomer

Are you interesting to a 5th grader?



Telemetry As Text

0	TX A Power	0.42	Watts	27	Low V I	100.00	Counts	54	Txt bcd ratio	6.00	Ratio
1	TX B Power	0.63	Watts	28	Bat I	831.31	mA	55	Bat Mgmt	0.00	State
2	Torqr Cap V	998.48	V	29	Tx I	0.98	Amps	56	WOD State	0.00	State
3	Bat V	8.53	V	30	Bat sign	49.00	Counts	57	EDAC Errors	184.00	Counts
4	Cell 5 V	7.18	V	31	SQRX RSSI	221.00	Counts	58	TXHang	0.00	Counts
5	Cell 4 V	5.71	V	32	SQRX Spkr	3869.00	Counts	59	CmdTmrLen	0.00	Secs
6	Cell 3 V	4.29	V	33	Torqr 1.2V ref	10.06	V	60	CmdTmrEnd1	0.00	Counts
7	Cell 2 V	2.87	V	34	Torqr Sense	4095.00	Counts	61	CmdTmrEnd2	0.00	Counts
8	Cell 1 V	1.43	V	35	Not Used	2042.00	Counts	62	WODTimeLeft	0.00	Mins
9	4.6V Exp I	110.86	mA	36	S Osc Temp	13.00	Deg C	63	Last Mode	---	Counts
10	4.6V Exp V	4.60	V	37	TX B Temp	-46.03	Deg C	64	spare	---	Counts
11	3.3V I	79.46	mA	38	Not Used	2047.00	Counts	65	EDAC A0	---	Adr
12	3.3V V	3.34	V	39	S PA Temp	13.63	Deg C	66	EDAC A1	---	Adr
13	Total Array I	1233.22	mA	40	Temp +Z	25.06	Deg C	67	EDAC A2	---	Adr
14	Total Array V	15.16	V	41	Not Used	2047.00	Counts	68	EDAC A3	---	Byte
15	+X I	383.88	mA	42	Temp +Y	15.02	Deg C	69	EDAC A4	---	Byte
16	-X I	25.70	mA	43	Temp -Y	13.29	Deg C	70	EDAC A5	---	Byte
17	+Y I	515.47	mA	44	Temp +X	14.45	Deg C	71	EDAC A6	---	Counts
18	-Y I	104.28	mA	45	Temp -X	13.77	Deg C	72	Auto TX Pwr	---	Counts
19	+Z I	183.54	mA	46	Bat 1 Temp	14.30	Deg C	73	BatMgmt State	---	Counts
20	-Z I	263.84	mA	47	Bat 2 Temp	13.68	Deg C	74	reserved	---	Counts
21	+X V	0.85	V	48	Main Reg Temp	28.31	Deg C	75	reserved	---	Counts
22	-X V	0.49	V	49	TX V Reg Temp	20.39	Deg C	76	reserved	---	Counts
23	+Y V	0.32	V	50	+4V #1 V	4.03	V	77	reserved	---	Counts
24	-Y V	0.49	V	51	+4V #2 V	4.03	V	128	Bat I	---	mA
25	+Z V	0.92	V	52	PHT time	20.00	Secs	129	Bat I	---	mA
26	-Z V	0.80	V	53	Digipeat	0.00	On/Off				

WOD timestamp = 2007 Apr 06 15:23:43

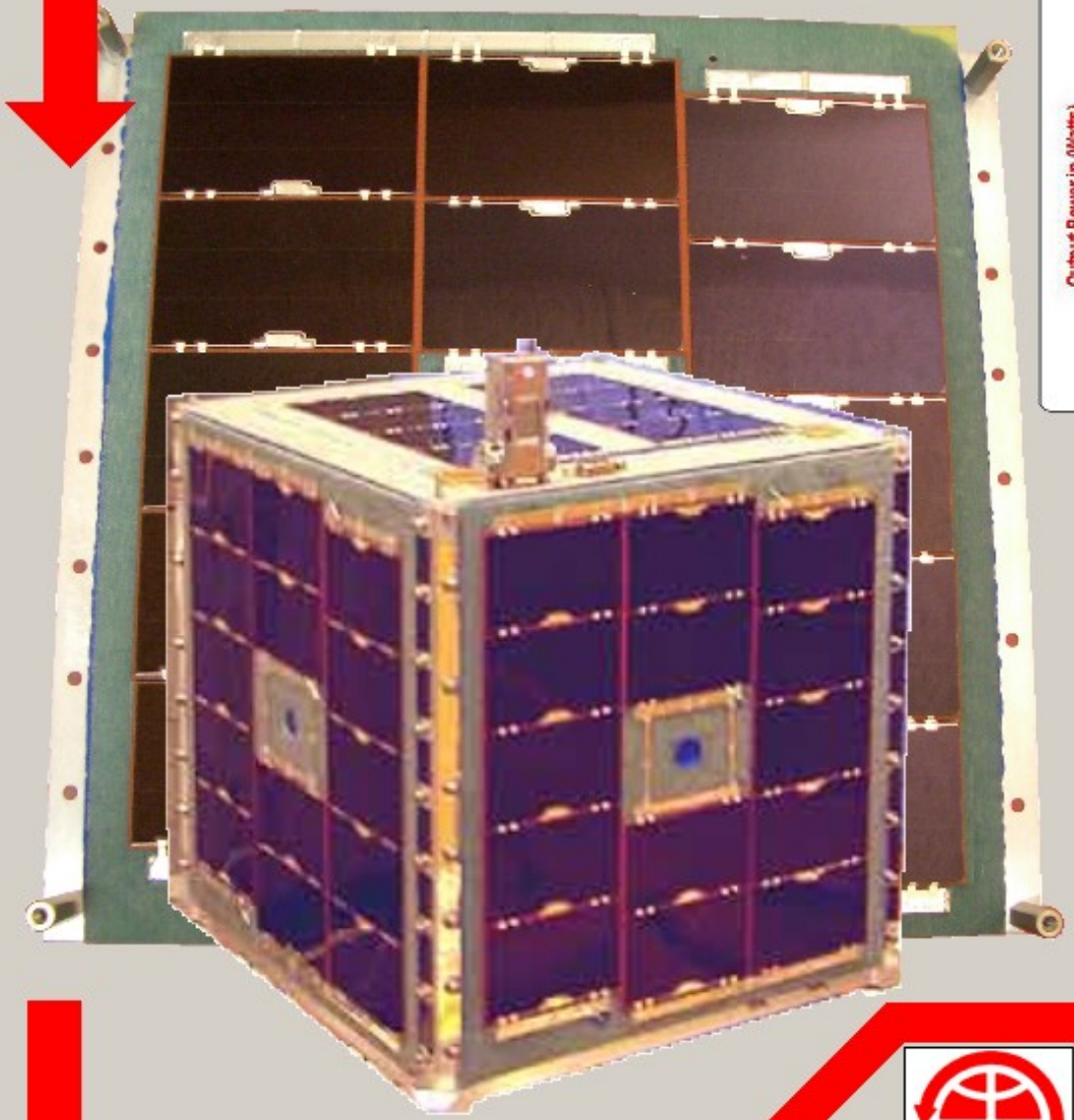
Display Raw Values

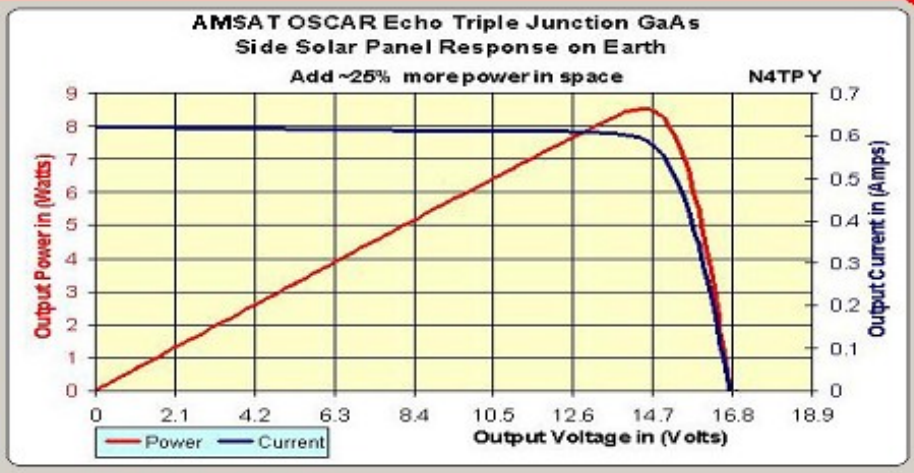
Legend:

This channel has changed

This value is outside the limits

Solar Panels



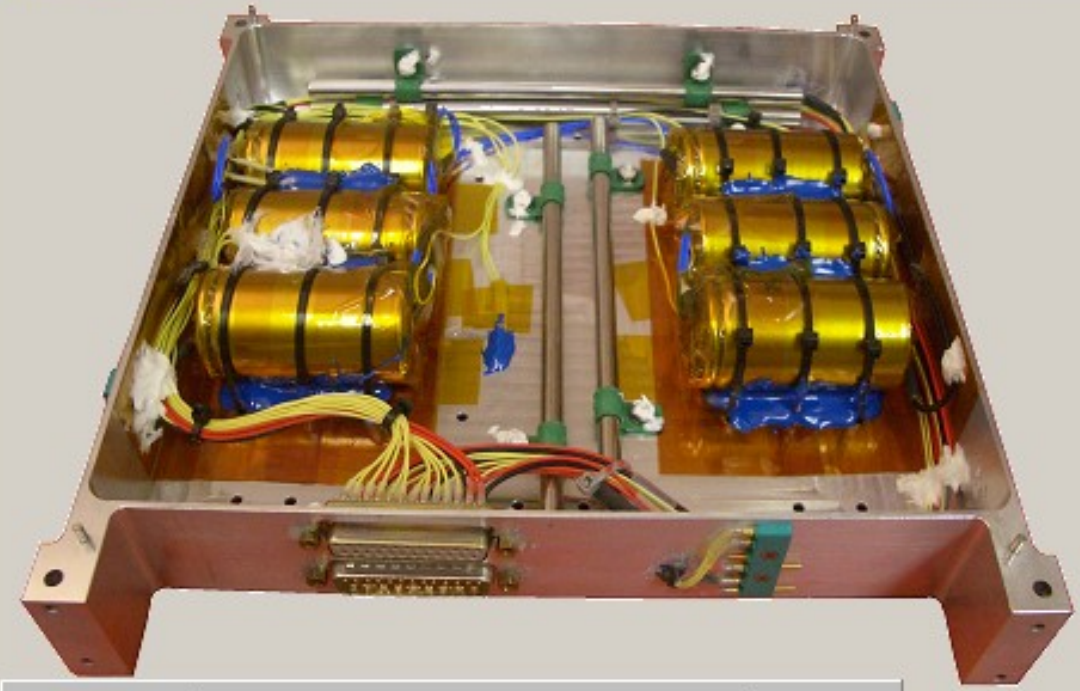


Z + Solar Panel		
	0.92	V
	81.27	mA
	-1.21	C
X + Solar Panel		
	0.85	V
	0.86	mA
	1.03	C
Y + Solar Panel		
	0.32	V
	26.20	mA
	0.97	C
X - Solar Panel		
	0.49	V
	30.65	mA
	1.57	C
Y - Solar Panel		
	0.49	V
	-0.45	mA
	2.27	C
Z - Solar Panel		
	0.80	V
	77.11	mA
		C

Total Voltage	1.13	V
Total Current	-5.69	mA

to BCR System

Battery / BCR



Batteries

Individual Battery Cells

#1	1.43 Volts	#4	1.42 Volts
#2	1.44 Volts	#5	1.47 Volts
#3	1.42 Volts	#6	1.35 Volts

Temperatures

14.30 degrees C

13.68 degrees C

Cumulative Voltages

#1	#2	#3	#4	#5	#6
1.43	2.87	4.29	5.71	7.18	8.53

Battery Voltage 8.53 Volts Battery Current 831.31 mA

Battery Control Regulator

Temperatures

Main V reg Temp 28.31 TX V Reg Temp 20.39

Regulated Voltages

3.3 Volt	3.34	4.6 Volt	4.60
3.3 mA	79.46	4.6 mA	110.86

Low Voltage mA	100.00	+4V #1	4.03 Volts
		+4V #2	4.03 Volts

BCR tray

Sabins – options

- Reads from KISS .KSS files (both “flavors”)
- Reads from Whole Orbit Data .WOD files
- Lets you single step through the telemetry one packet at a time to watch changes

- Receives telemetry “live” over a TCPIP connection from either Willow (on the same computer) or an Internet telemetry server

The Future

- Multiple simple ground stations with Internet conections and a centralized telemetry “exploder” (similar to “AO40Rcv + P3t”)